Attachment 10

ENVIRONMENTAL PERFORMANCE STANDARDS AND HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENTS

ENVIRONMENTAL PERFORMANCE STANDARDS AND HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENTS

1.0 General

This section addresses the ability of OB/OD operations at the UTTR-North TTU to meet environmental performance standards that protect groundwater, surface water, soil, and air quality. As a result of OB/OD activities, these media have the greatest chance of becoming exposure pathways for the migration of hazardous materials to potential human and environmental receptors.

Studies of early OB/OD operations by the AEHA revealed some common practices responsible for suspected releases of contaminants to these media, leading to revisions of DoD OB/OD operating procedures (AEHA 1986). These recommendations included the use of burn pans for OB, operating only under favorable meteorological conditions, employing more detailed reporting and recordkeeping practices, and being more discrete in the selection of materials to be thermally treated by OB/OD processes. These procedures are discussed in more detail in Attachment 1.

The following sections describe the environmental performance requirements, potential exposure pathways, and health risks that will result from TTU operations. Discussions of the environmental performance standards and site-specific conditions for groundwater, surface water, soil, air, and noise and shock precede the assessments of the health risks for each potential exposure route.

2.0 Groundwater Pathway [40 CFR 264.601(a) and R315-8-16]

2a. Performance Standards

The environmental performance standard for protection of groundwater calls for the prevention of any releases that may adversely affect human health or the environment due to migration of waste constituents in the groundwater or subsurface environments. Specific items to be considered include:

- The volume and chemical characteristics of the waste in the unit;
- The hydrogeologic and geologic characteristics of the unit and surrounding area;
- The existing quality of groundwater;
- The quantity and direction of groundwater flow;
- The proximity to and withdrawal rates of current and potential groundwater users;
- The patterns of land use in the region;
- The potential for deposition or migration of waste constituents into the subsurface, physical structures, and the root zone of food chain crops and other vegetation;
- The potential for health risks caused by human exposure to waste constituents;
- The potential for damage to domestic animals, wildlife, crops, vegetation, and physical structures caused by exposure to waste constituents.

2b. Required Programs

Utah regulations require groundwater monitoring and reporting for all hazardous waste management facilities unless a waiver is granted. The groundwater monitoring program consists of detection monitoring, compliance monitoring, and monitoring during and after corrective actions.

2c. Site-Specific Conditions

Groundwater and geologic conditions beneath the TTU facility were investigated in 1991 through monitoring wells JMM-TTU-1 and JMM-TTU-2 (see Figure B-2). Boreholes for the wells revealed extensive thicknesses of unsaturated, low-permeability soils. Groundwater in an unnamed aquifer occurs at depths ranging from 450 ft near the southwest corner of the facility to 650 ft beneath the ridge at Sedal Pass above the TTU. Based on groundwater levels in the upgradient and downgradient monitoring wells, depth to groundwater beneath the three OB/OD units is estimated to be greater than 585 ft.

Groundwater samples collected from the wells at TTU-1 and TTU-2 since 1994 were analyzed for energetics and metals. Table E-1 shows the detected analytes. Samples were also collected from Well G, just outside the southeast corner of the TTU and adjacent to Landfill 5 (see Figure B-2). No sampling protocol is available for past sampling practices.

Analytical results to date show seven metals (calcium, iron, magnesium, manganese, potassium, sodium, and zinc) were present in most groundwater samples taken from both wells (see Table E-1). Each is commonly found in area soils. One energetic (nitrobenzene) was detected in one sample taken from one monitoring well (TTU-1). All analyses included equipment blanks and matrix spikes (MSs) and were completed by environmental laboratories certified by the State of Utah.

The information in Table 1 suggests there has been no groundwater contamination resulting from OB/OD activities at the TTU. This is expected since there is limited to no potential for groundwater contamination from this facility because:

- The groundwater in the principal aquifer is unsuitable for human consumption without treatment;
- Groundwater occurs at greater than 400 to 600 ft bgs;
- The average annual precipitation is generally low (i.e., approximately 6 in./year);
- The potential for evapotranspiration is high; and

_ The soil deposits exhibit low permeability characteristics.

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_ The potential for evapotranspiration is high; and

_ The soil deposits exhibit low permeability characteristics.

Therefore, groundwater sampling is not proposed as part of the SAP since this facility does not pose an unacceptable risk to human health or the environment from this pathway.

USGS well records for four nearby wells (within 7 miles) are shown in Table 2. Current groundwater users withdraw water through three of these wells. Two of the wells are pumped to supply Oasis with water; the third is used intermittently for stock watering by non-resident sheepherders. The fourth well, which lies east of the TTU, is owned by the AF and is not currently used.

Table 1. TTU Groundwater Monitoring Well Sampling Results

Date	Well	Energetics[a] (□g/L)	Metals[b] (mg/L)						
			Cal-cium	Iron	Magnesium	Manganese	Potassium	Sodium	Zinc
3 February 1994	TTU-1	ND	59.0	0.085	24.5	0.023	36.4	314	ND
	TTU-2	ND	116	0.20	58.8	0.017	36.1	371	ND
11 April 1994	TTU-1	ND	61.8	ND	23.4	ND	31.2	ND	ND
	TTU-2	ND	115	ND	57.9	ND	33.4	355	ND
26 July 1994	TTU-1	ND	56.9	0.075[c]	24.7	ND	39.1	318	ND
	TTU-2	ND	112	ND	61.2	ND	37.3	367	ND
18 October 1994	TTU-1	ND	68.3	ND	27.5	ND	38.5	319	ND
	TTU-2	ND	116	ND	61.2	ND	36.2	366	ND
3 March 1995	TTU-1	0.25[d]	61.1	ND	26.2	ND	37.4	320	ND
	TTU-2	ND	119	ND	61.3	ND	36.2	371	ND
28 April 1995	TTU-1	ND	58.7	0.12	24.6	ND	36.4	309	0.019
	TTU-2	ND	115	ND	61.0	ND	36.1	367	ND
27 July 1995[e]	TTU-1	-	-	-	-	-	-	-	-
	TTU-2	-	-	-	-	-	-	-	-
23 October 1995	TTU-1	ND	58.5	ND	24.6	ND	36.1	307	0.010
	TTU-2[f]	ND	107	ND	54.6	ND	31.9	325	0.23
12 January 1997	TTU-1[f]	ND	61.8	ND	26.2	ND	37.1	322	ND
	TTU-2[f]	ND	119	ND	61.3	ND	35.6	371	0.33
4 April 1996	TTU-1[f]	ND	54.4	ND	23.0	ND	33.9	282	0.014
	TTU-2[f]	ND	105	ND	54.9	ND	32.5	330	0.16
26 April 1997	TTU-1[f]	ND	62.1	ND	25.7	ND	36.5	304	0.084
	TTU-2[f]	ND	108	ND	57.7	ND	33.8	335	0.014

[a] Picric acid; nitroglycerine; PETN; nitroguanidine; nitrobenzene; 2,4-DNT; 2,6-DNT; 2,4,6-TNT; RDX; HMX; 2-amino-4,6-DNT.
[b] Aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, molybdenum, nickel, potassium, selenium, silver, thallium, vanadium, and zinc.
[c] High level in the equipment blank suggests this value may be biased high.
[d] Nitrobenzene.
[e] TTU-1 and TTU-2 not sampled.
[f] Sampled for dissolved metals.

As shown in Table 2, groundwater in the area contains moderate to high concentrations of TDS, chloride, and sodium, which limits its usefulness for many applications. According to Price (1970), the groundwater in the Sink Valley Hydrologic Basin is unsuitable for irrigation, but there is sufficient groundwater locally to support some industrial development for which the chemical quality of water is not a limiting factor. However, the groundwater throughout the area is too highly mineralized for any industry that requires water with a TDS concentration less than 2,000 mg/L. Low TDS water for industries or for domestic supplies must be transported into the area, as was done at the railroad camp at Lakeside, or pumped from the groundwater sources and demineralized, as is done at the support compound of Oasis.

As discussed in Attachment 1, the amount of groundwater recharged due to infiltration is slight. Groundwater recharge in the vicinity of the TTU enters the groundwater system only along the margins of the adjacent mountains where coarser-grained sediments are present.

2d. Assessment of Potential Health Risks

Analytical results demonstrate that groundwater beneath the TTU has not been impacted by OB/OD activities. This, coupled with the following facts, make it extremely unlikely anyone would be at risk because of TTU activities by drinking from the same groundwater source that lies beneath the TTU.

Table 2. Chemical Analysis of Pre-Treatment Water from UTTR-North Production Wells

Test	EPA Method	Well No. 1 (mg/L)	Well No. 2 (mg/L)
Sodium	200.7	2,797.870	1,901.230
Antimony	204.2	0.080	0.008
Arsenic	206.2	0.110	0.076
Barium	200.7	<0.100	<0.100
Beryllium	210.2	<0.001	<0.001
Cadmium	213.2	0.001	0.001
Calcium	200.7	60.400	32.000
Chromium	200.7	<0.050	<0.050
Magnesium	200.7	117.000	76.000
Hardness	—	631.000	395.500
Iron	200.7	0.389	0.215
Manganese	200.7	<0.050	<0.050
Mercury	295.2	<0.001	<0.001
Nickel	200.7	<0.050	<0.050
Potassium	200.7	80.000	63.000
Selenium	270.2	1.005	0.788
Silver	200.7	<0.005	<0.005
Thallium	279.2	<0.002	<0.002
Zinc	200.7	0.090	0.177
Lead	239.2	0.010	0.060
Copper	200.7	<0.020	<0.020
Oil and Grease	413	0.300	0.300
Nitrate	353.2	8.400	2.600
Nitrite	353.2	<0.200	<0.020
Cyanide	335.3	0.005	<0.005
Chloride	325.2	3,480.000	4,400.000
Fluoride	380.76	4.800	6.000
Sulfate	300.10	540.000	660.000

Source: Armstrong Laboratory, Brooks AFB, TX, Reports of Analysis, May-Sep 1993.

_ The area receives less than 6 in. of precipitation per year; the soil and rock beneath the TTU have low vertical permeabilities; and groundwater is more than 400 ft bgs.

_ All wells in the vicinity have low specific yields; before any groundwater can be considered potable, it must be treated to remove impurities.

_ Water users in the area are located more than 5 miles from the TTU.

3b. Required Programs

The "Draft Permit Writers Guidance for OB/OD Treatment Facilities," April 1996, requires sampling of surface waters and wetlands within and contiguous to the OB/OD units.

3c. Site-Specific Conditions

As indicated in Section B, there are no permanent surface water bodies within the confines of the TTU or in the surrounding area. However, as shown in Figure B-1, there is an erosional dry wash located topographically below the TTU subunits. Annual precipitation in and around the TTU is generally less than 6 in./year.

Because the TTU subunits are located near the top of the precipitation catchment basin, there is little potential for surface water runoff collecting in the subunits. In addition, as shown in Figure 1, a distance of more than 1/2 mile lies between the closest subunit and the dry wash. Surface water is present in the dry wash infrequently during major storm events, and the natural topography directs the flow away from active portions of the TTU.

The closest surface water body to the TTU is the Great Salt Lake, which lies approximately 3 miles eastward. Because the TTU is located on the west side of the Lakeside Mountain Range, surface water runoff from the TTU facility is directed to the west, away from the

Great Salt Lake, into the Sink Valley, which is a closed, internally drained basin.

For these reasons, surface water resources in the vicinity will not be affected by OB/OD operations at the TTU. In addition, there are no known surface water pathways from the TTU subunits to any human or environmental receptors.

3d. Assessment of Potential Health Risks

The surface water pathway is incomplete since there are no surface water bodies into which contaminants could migrate. Therefore, there is no potential for health risks from this pathway.

4.0 <u>Surface Soil [40 CFR 264.601(b) and R315-8-16]</u>

4a. Performance Standards

The environmental performance standard for soil is similar to that of surface water, in that it calls for the prevention of any releases that may have adverse effects on human health or the environment due to migration of waste constituents in surface water or in wetlands. The considerations described in Section E-3a are applicable here.

4b. Required Programs

The "Draft Permit Writers Guidance for OB/OD Treatment Facilities," April 1996, requires sampling of surface soil within and contiguous to the OB/OD units' area of impact.

4c. Site-Specific Conditions

Information regarding the chemical nature of surface soils was obtained through two soil sampling programs conducted at the TTU. In the first program, conducted in 1989 (SAIC

1989), five samples were collected in a preliminary study of the munitions burn pit adjacent to what is now Site 3 in Figure 1. Four of the five samples were taken from the top 2 in. of soil in the bottom of the pit. The fifth sample was taken to represent background conditions approximately 150 to 200 yards east of Site 3. Figure 1 depicts the sampling locations. The results of the laboratory analytical program are presented in Tables 3 and 4.

These tables include results of the four samples, a duplicate, and three other QA/QC samples. In the second soil sampling program conducted in 1991 (JMM 1991b), 20 samples of surface soil and 3 QA/QC samples were collected from various locations at each site and from background locations at the TTU. Table 5 summarizes the sampling locations, analytes, and concentrations of the various compounds present in these soil samples.

Figure 1. Locations of Surface Soil Samples in the TTU

Table 3. Soil Sampling Results for SVOCs and Miscellaneous Compounds

Compound	TTU-SS01S	TTU-SS02S	TTU-SS03S	TTU-SS04S(D)	TTU-SS05S	TTU-SS06S(BG)	FB-1 (µg/L)	FB-2 (µgL)	EW-1 (µg/L)
Acenaphthene	<0.33	2J	24	<21	11	<0.36	<0.01	<0.01	<0.01
Acenaphthylene	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01
Anthracene	<0.33	<20	3.6J	3.7J	<7.1	<0.36	<0.01	<0.01	<0.01
Benzo (a) anthracene	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01
Benzo (a) pyrene	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01
Benzo (b) fluoranthene	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01
Benzo (g,h,i) perylene	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01
Benzo (k) fluoroanthene	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01
Benzoic acid	<1.6	<96	<100	<100	<35	<1.8	<0.05	<0.05	<0.05
Benzyl alcohol	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01
bis (2-Chloroethyl) ether	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01
bis (2-Chloroisopropyl) ether	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01
bis (2-Ethylhexyl) phthalate	0.15JB	1.2JB	1.5JB	<21	0.37JB	<0.087JB	<0.01	0.02B	<0.01
4-Bromophenyl-phenylether	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01
Butylbenzylphthalate	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01
2-Chloronaphthalene	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01
2-Chlorophenol	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01
4-Chloro-3-methylphenol	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01
4-Chloroaniline	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01
4-Chlorophenyl-phenylether	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01
Chrysene	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01
Di-n-butylphthalate	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01
Di-n-octylphthalate	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01
Dibenzo (a,h) anthracene	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01
Dibenzofuran	<0.33	0.64J	12J	10J	5.2J	<0.36	<0.01	<0.01	<0.01
1,2-Dichlorobenzene	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01
1,3-Dichlorobenzene	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01
1,4-Dichlorobenzene	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01
3,3'-Dichlorobenzidine	<0.66	<40	<42	<42	<14	<0.72	<0.02	<0.02	<0.02
2,4-Dichlorophenol	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01
Diethylphthalate	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01

Table 3. Soil Sampling Results for SVOCs and Miscellaneous Compounds

Compound	TTU-SS01S	TTU-SS02S	TTU-SS03S	TTU-SS04S(D)	TTU-SS05S	TTU-SS06S(BG)	FB-1 (µg/L)	FB-2 (µgL)	EW-1 (µg/L)
2,4-Dimethylphenol	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01
Dimethylphthalate	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01
2,4-Dinitrophenol	<1.6	<96	<100	<100	<35	<1.8	<0.05	<0.05	<0.05
2,4-DNT	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01
2,6-DNT	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01
4,6-Dinitro-2-methylphenol	<1.6	<96	<100	<100	<35	<1.8	<0.05	<0.05	<0.05
Fluoranthene	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01
Fluorene	<0.33	1.7J	33	26	18	<0.36	<0.01	<0.01	<0.01
Hexachlorobenzene	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01
Hexachlorobutadiene	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01
Hexachlorocyclopentadiene	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01
Hexachloroethane	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01
Indeno (1,2,3-cd) pyrene	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01
Isophorone	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01
2-Methylnaphthalene	0.41J	18J	170	150	77	<0.36	<0.01	<0.01	<0.01
2-Methylphenol	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01
4-Methylphenol	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01
N-Nitroso-di-n-propylamine	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01
N-Nitrosodiphenylamine	<0.33	<20	<21	<21	<7.1	<0.36	>0.01	<0.01	<0.01
Naphthalene	0.32J	3.6J	53	47	23	<0.36	<0.01	<0.01	<0.01
2-Nitroaniline	<1.6	<96	<100	<100	<35	<1,8	(0.05	<0.05	<0.05
3-Nitroaniline	<1.6	<96	<100	<100	<35	<1.8	<0.05	<0.05	<0.05
4-Nitroaniline	<1.6	<96	<100	<100	<35	<1.8	<0.05	<0.05	<0.05
Nitrobenzene	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01
2-Nitrophenol	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01
4-Nitrophenol	<1.6	<96	<100	<100	<35	<1.8	<0.05	<0.05	<0.05
Pentachlorophenol	<1.6	<96	<100	<100	<35	<1.8	<0.05	<0.05	<0.05
Phenanthrene	0.38J	8.9J	92	60	51	<0.36	<0.01	<0.01	<0.01
Phenol	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01
Pyrene	<0.33	1.0J	5.4J	4.8J	3.5J	<0.36	<0.01	<0.01	<0.01
1,2,4-Trichlorobenzene	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01
2,4,5-Trichlorophenol	<1.6	<96	<100	<100	<35	<1.8	<0.05	<0.05	<0.05
2,4,6-Trichlorophenol	<0.33	<20	<21	<21	<7.1	<0.36	<0.01	<0.01	<0.01

Table 3. Soil Sampling Results for SVOCs and Miscellaneous Compounds

Compound	TTU-SS01S	TTU-SS02S	TTU-SS03S	TTU-SS04S(D)	TTU-SS05S	TTU-SS06S(BG)	FB-1 (µg/L)	FB-2 (µgL)	EW-1 (µg/L)
Nitrate	1.5	1.6	1.8	1.6	8.5	5.4	0.35	<0.05	<0.05
Total petroleum hydrocarbons	210	4800	47,000	47,000	38,000	20	<0.5	<0.5	<0.5

Source: SAIC 1990.

Notes: Units are mg/kg unless otherwise noted. D = duplicate of previous sample; J = estimated concentration; B = detected in laboratory blank; FB = field blank; BG = background sample; EW = equipment wash.

Table 4. 1989 Soil Sampling Results for Heavy Metals

Compound	TTU-SS01S	TTU-SS02S	TTU-SS03S	TTU-SS04S(D)	TTU-SS05S	TTU-SS06S(BG)	FB-1 (mg/L)	FB-2 (mg/L)	EW-1 (mg/L)
Aluminum	7980E	9280E	9950E	8630E	9340E	14,600E	<0.064	<0.064	<0.064
Antimony	<1.7	6.4B	<1.7	<1.7	<1.6	<1.7	<0.010	<0.010	<0.010
Arsenic	5.7	7.0S	9.6S	7.0	7.4	5.9	<0.001	<0.001	<0.001
Barium	153N	162N	161N	136N	159N	181N	<0.026	<0.026	<0.026
Beryllium	<0.17	<0.15	<0.17	<0.17	<0.16	0.30B	<0.001	<0.001	<0.001
Cadmium	<0.84	2.1	0.98	<0.87	0.83	0.90	<0.005	<0.005	<0.005
Chromium	9.7	23.6	10.8	8.3	9.0	12.6	<0.006	<0.006	<0.006
Cobalt	<4.7	<4.2	<4.8	<4.9	<4.6	<4.6	<0.028	<0.028	<0.028
Copper	78.0E*	94.7E*	15.3E*	82.6E*	83.7E*	14.1E*	<0.009	<0.009	<0.009
Lead	24.8*	811S*	160*	111*	18.5*	16.1*	0.0017	0.001	0.0018
Manganese	181E	219E	189E	139E	219E	345E	<0.006	<0.006	<0.006
Mercury	<0.09	<0.01	<0.11	<0.11	<0.11	<0.11	<0.0002	<0.0002	<0.0002
Nickel	9.0N	10.2N	7.5N	6.7BN	10.4N	13.9N	<0.038	<0.038	<0.038
Selenium	<1.6N	<1.5N	<1.7N	<1.7N	<1.8N	<1.7N	0.0038B	<0.002	<0.002
Silver	<0.67N	4.0N	<0.68N	<0.70N	<0.66N	<0.66N	<0.004	<0.004	<0.004
Thallium	0.22B	0.22B	<0.17	<0.17	0.42B	0.24B	<0.001	<0.001	<0.001
Vanadium	14.9N	16.5N	16.4N	13.1N	17.0N	19.2N	<0.019	<0.019	<0.019
Zinc	60.7	88.7	59.7	43.2	66.8	48.3	0.170	<0.013	0.020

Source: SAIC 1990.: Units are mg/kg unless otherwise noted. D = duplicate of previous sample; BG = background sample; FB = field blank; EW = equipment wash; E = value is estimated due to matrix interferences; N = spiked sample recovery not within control limits; B = reported value is less than the contract required detection limit, but greater than the instrument detection limit; S = reported value was determined by the method of standard additions; * = duplicate analysis was not within control limits.

Samples from the 1989 sampling program were analyzed for SVOCs and metals. Of the SVOC analytes, only a small number of polyaromatic hydrocarbons were detected. Of these, acenaphthene, fluorene, methylnaphthalene, naphthalene, and phenanthrene were present in detectable concentrations. None of these compounds are classified as carcinogens.

Analysis for metals revealed detectable concentrations of arsenic, cadmium, chromium, and lead. Arsenic was detected at 5.9 mg/kg in the background sample and from 5.7 to 9.6 mg/kg in samples collected from the pit. Cadmium was detected at 0.90 mg/kg in the background sample, while samples from the pit ranged from 0.83 to 2.1 mg/kg. Chromium was detected at 12.6 mg/kg in the background sample, while samples from the pit ranged from 8.3 to 23.6 mg/kg. The lead concentration was 16.1 mg/kg in the background sample, while concentrations as high as 811 mg/kg were present in samples from the pit.

Soil samples from the 1991 soil sampling program were analyzed for metals, explosives, and selected anions. Elevated levels of several metals and explosives were present. Samples SS-1 through SS-4 were collected from Site 1. The only anomalous value present in these samples was an elevated level of copper at 18,000 mg/kg.

Samples SS-5 through SS-9 and SS-21 (a blind duplicate of SS-9) were collected from around Site 3. The blind duplicate pair (SS-9 and SS-21) was taken from the bottom of the burn pan itself. Analyses of these samples revealed elevated levels of aluminum, cadmium, copper, lead, and zinc, and trace explosives (HMX, 2,4-DNT, and nitroguanidine).

Samples SS-10 through SS-15 were collected from Site 2. Analysis of these samples indicates that traces of explosives are present in the shallow soils in this area. HMX was present in two samples from the OD areas at 7 and 25 mg/kg. The sample with the higher concentration was collected from the bottom of an OD crater. In addition to HMX, trace levels of nitroguanidine and picric acid were also detected.

Table 5 - 1991 Soil Sampling Results

Analyte	SS-1: Center of Site 1 Staging Area	SS-2: Site 1, Motor Burn Area	SS-3: Site 1, Bulk Propellant Burn Area	SS-4: North Edge of Site 1 Staging Area	SS-5: West Wall of Site 3
Barium	140	110	160	170	240
Beryllium	<1	<1	<1	<1	<1
Cadmium	<1	<1	<1	<1	14
Calcium	120000	190000	210000	190000	150000
Chromium	13	18	30	17	25
Copper	6	<1	18000	19	410
Iron	9600	6100	6900	7800	15000
Manganese	270	140	120	200	320
Magnesium	15000	9700	13000	14000	14000
Nickel	8	9	19	8	31
Potassium	4000	2500	1300	3400	3600
Silver	<2	<2	<2	<2	<2
Sodium	1200	1000	580	1800	1000
Aluminum	11000	7900	20000	9600	11000
Zinc	43	34	60	36	2300
Arsenic	<10	<10	<10	<10	<10
Lead	12	<2	34	<2	48000
Selenium	<10	<10	<10	<10	<10
Thallium	<5	<5	<5	<5	<5
Phosphorus	460	450	990	470	500
Mercury	<0.05	<0.05	<0.05	<0.05	<0.05
Chloride (mg/g)	0.1	<0.1	0.3	0.1	0.1
Sulfate (mg/g)	<0.5	<0.5	16	<0.5	<0.5
Nitrates (mg/g)	0.007	0.009	0.009	0.045	0.013
pH (unitless)	8.1	8.9	8.2	8	8.1
PETN	<1	<1	<1	<1	<1
Nitroglycerin	<0.51	<0.51	<0.51	<0.51	<0.51
HMX	<3	<3	<3	<3	8
RDX	<3	<3	<3	<3	<3
Nitrobenzene	<3	<3	<3	<3	<3
2,4,6-TNT	<3	<3	<3	<3	<3
2,6-DNT	<3	<3	<3	<3	<3
2,4-DNT	<2	<2	<2	<2	2
2-Amino-4,6-DNT	<3	<3	<3	<3	<3
Nitroguanidine	<0.1	<0.1	<0.1	<0.1	<0.1
Picric acid	<0.2	<0.2	<0.2	<0.2	<0.2

Notes: All concentrations in mg/kg unless noted otherwise.

Table 5. (Continued)

Analyte	SS-6: North-west Corner of Site 3	SS-7: West Edge of Site 3	SS-8: 100 ft East of Site 3	SS-9: Bottom of Site 3	SS-10: Center of Site 2, Pad 1
Barium	220	200	200	210	190
Beryllium	<1	<1	<1	<1	<1
Cadmium	<1	<1	<1	32	<1
Calcium	140000	190000	160000	150000	120000
Chromium	18	22	15	14	15
Copper	59	950	30	140	52
Iron	14000	14000	11000	11000	12000
Manganese	410	330	310	280	290
Magnesium	19000	14000	14000	13000	16000
Nickel	11	17	8	9	8
Potassium	5300	3500	4400	3600	4900
Silver	<2	<2	<2	<2	<2
Sodium	1300	1300	690	1300	1400
Aluminum	16000	13000	13000	54000	14000
Zinc	130	490	63	240	51
Arsenic	<10	<10	<10	<10	<10
Lead	80	1500	65	140	36
Selenium	<10	<10	<10	<10	<10
Thallium	<5	<5	<5	<5	<5
Phosphorus	700	570	570	500	460
Mercury	<0.05	<0.05	<0.05	<0.05	<0.05
Chloride (mg/g)	0.2	0.2	<0.1	0.3	<0.1
Sulfate (mg/g)	<0.5	<0.5	<0.5	<0.5	<0.5
Nitrates (mg/g)	0.009	0.026	0.015	0.007	0.009
pH (unitless)	8.1	8.2	8	8.5	8.2
PETN	<1	<1	<1	<1	<1
Nitroglycerin	<0.51	<0.51	<0.51	<0.51	<0.51
HMX	3	<3	4	<3	<3
RDX	<3	<3	<3	<3	<3
Nitrobenzene	<3	<3	<3	<3	<3
2,4,6-TNT	<3	<3	<3	<3	<3
2,6-DNT	<3	<3	<3	<3	<3
2,4-DNT	<2	<2	<2	<2	<2
2-Amino-4,6-DNT	<3	<3	<3	<3	<3
Nitroguanidine	<0.1	<0.1	<0.1	0.1	0.3
Picric acid	<0.2	<0.2	<0.2	<0.2	<0.2

Notes: All concentrations in mg/kg unless noted otherwise.

Table 5. (Continued)

Analyte	SS-11: West of Site 2, Pad 1	SS-12: North-west Portion of Site 2, Pad 2	SS-13: Bottom of Crater Site 2, Pad 2	SS-14: Center of Site 2, Pad 3	SS-15: West Portion of Site 2, Pad 3
Barium	240	200	640	190	200
Beryllium	<1	<1	<1	<1	<1
Cadmium	<1	<1	<1	<1	<1
Calcium	100000	120000	140000	130000	120000
Chromium	18	18	14	17	16
Copper	38	79	49	25	12
Iron	14000	14000	12000	15000	14000
Manganese	480	440	350	360	410
Magnesium	22000	19000	19000	18000	19000
Nickel	12	11	9	10	11
Potassium	5500	5400	4200	5900	6300
Silver	<2	<2	<2	<2	<2
Sodium	710	1200	1300	1000	1700
Aluminum	17000	20000	17000	20000	18000
Zinc	63	75	68	61	56
Arsenic	<10	<10	<10	<10	<10
Lead	30	67	300	24	19
Selenium	<10	<10	<10	<10	<10
Thallium	<5	<5	<5	<5	<5
Phosphorus	730	590	500	660	750
Mercury	<0.05	<0.05	0.07	<0.05	<0.05
Chloride (mg/g)	<0.1	<0.1	<0.1	<0.1	<0.1
Sulfate (mg/g)	<0.5	<0.5	<0.5	<0.5	<0.5
Nitrates (mg/g)	0.015	0.043	0.11	0.007	0.006
pH (unitless)	7.5	7.7	8.2	8	8.1
PETN	<1	<1	<1	<1	<1
Nitroglycerin	<0.51	<0.51	<0.51	<0.51	<0.51
HMX	<3	7	25	<3	<3
RDX	<3	<3	<3	<3	<3
Nitrobenzene	<3	<3	<3	<3	<3
2,4,6-TNT	<3	<3	<3	<3	<3
2,6-DNT	<3	<3	<3	<3	<3
2,4-DNT	<1	<1	<1	<1	<1
2-Amino-4,6-DNT	<3	<3	<3	<3	<3
Nitroguanidine	<0.1	<0.1	<0.1	<0.1	<0.1
Picric acid	0.3	<0.2	<0.2	<0.2	<0.2

Note: All concentrations in mg/kg unless noted otherwise.

Table 5. (Continued)

Analyte	SS-16: Background at Crest of Ridge Above Site 1	SS-17: Background at South Central TTU	SS-18: Background Southwest of TTU	SS-19: Background Northwest of TTU	SS-19MS: QA Sample
Barium	230	210	220	180	310
Beryllium	<1	<1	<1	<1	6
Cadmium	3	<1	<1	<1	5
Calcium	150000	66000	77000	100000	120000
Chromium	15	13	16	12	22
Copper	42	15	15	18	33
Iron	12000	13000	13000	10000	11000
Manganese	400	490	430	390	460
Magnesium	17000	22000	20000	17000	19000
Nickel	9	9	11	7	31
Potassium	4300	6100	6800	4200	4700
Silver	<2	<2	<2	<2	<2
Sodium	560	870	910	460	530
Aluminum	14000	14000	17000	12000	14000
Zinc	67	55	55	51	82
Arsenic	<10	<10	<10	<10	120
Lead	34	36	29	28	54
Selenium	<10	<10	<10	<10	92
Thallium	<5	<5	<5	<5	84
Phosphorus	860	820	830	820	930
Mercury	<0.05	<0.05	<0.05	<0.05	<0.05
Chloride (mg/g)	<0.1	0.1	0.1	<0.1	0.4
Sulfate (mg/g)	<0.5	<0.5	<0.5	<0.5	0.8
Nitrates (mg/g)	0.004	0.011	0.01	0.008	0.018
pH (unitless)	7.4	7.7	7.8	7.4	7.4
PETN	<1	<1	<1	<1	33.5
Nitroglycerin	<0.51	<0.51	<0.51	<0.51	16.7
HMX	<3	<3	<3	<3	34
RDX	<3	<3	<3	<3	29
Nitrobenzene	<3	<3	<3	<3	34
2,4,6-TNT	<3	<3	<3	<3	26
2,6-DNT	<3	<3	<3	<3	33
2,4-DNT	<2	<2	<2	<2	28
2-Amino-4,6-DNT	<3	<3	<3	<3	<3
Nitroguanidine	<0.1	<0.1	<0.1	<0.1	0.7
Picric acid	<0.2	0.4	<0.2	0.5	0.8

Note: All concentrations in mg/kg unless noted otherwise.

Table 5. (Continued)

Analyte	SS-19MSD: (Matrix Spike Duplicate) QA Sample	SS-20: Background at North Central TTU	SS-21: Blind Duplicate of SS-9 QA Sample
Barium	200	190	200
Beryllium	<1	<1	<1
Cadmium	<1	<1	45
Calcium	110000	82000	150000
Chromium	14	14	69
Copper	17	19	1000
Iron	11000	14000	11000
Manganese	420	460	370
Magnesium	18000	22000	13000
Nickel	8	10	12
Potassium	4700	5100	3900
Silver	<2	<2	7
Sodium	540	580	1600
Aluminum	14000	15000	93000
Zinc	53	57	480
Arsenic	<10	<10	<10
Lead	33	22	21
Selenium	<10	<10	<10
Thallium	<5	<5	<5
Phosphorus	880	890	630
Mercury	<0.05	<0.05	<0.05
Chloride (mg/g)	0.4	<0.1	0.3
Sulfate (mg/g)	0.8	<0.5	<0.5
Nitrates (mg/g)	0.019	0.008	0.007
pH (unitless)	7.4	7.5	8.4
PETN	33.2	<1	<1
Nitroglycerin	17.2	<0.51	<0.51
HMX	28	<3	<3
RDX	25	<3	<3
Nitrobenzene	25	<3	<3
2,4,6-TNT	22	<3	<3
2,6-DNT	27	<3	<3
2,4-DNT	23	<1	<1
2-Amino-4,6-DNT	<3	<3	<3
Nitroguanidine	0.7	<0.1	<0.1
Picric acid	0.9	0.4	<0.2

Note: All concentrations in mg/kg unless noted otherwise.

Samples SS-16 through SS-20 were collected from various background locations across the TTU. Analysis of these samples identified traces of picric acid in three of the five samples. This suggests the background samples do not actually represent background conditions. A comparison to data generated by Shacklette (1984) indicates that cadmium, copper, lead, and zinc are the metals present in the surface soils at concentrations above background throughout the western United States.

Samples SS-19MS and SS-19MSD were MS and matrix spike duplicate (MSD) splits from sample SS-19. Results of the spiking procedure are presented in Table E-6, while Table 7 presents a summary of the results of the blind duplicate analyses. The MS/MSD QA sample results show generally good agreement between the recoveries of spiking compounds. The blind duplicate QA sample results also show fairly good agreement, although some variability in the metals concentrations is apparent. This is probably due to inhomogeneties in the sample split and not because of laboratory imprecision. The results of QA/QC sample analyses indicate that the soil sample data are valid without any qualifications.

As discussed in Attachment 3, additional samples of the OB/OD residuals are collected on a regular basis. Specific information on the residual and soil sampling protocols is included in Section D of the Permit Application.

4d. Assessment of Potential Health Risks

A risk assessment was conducted to determine whether the metals and explosives present in surface soils above background concentrations present a significant potential threat to human health or the environment (JMM 1991a). It was assumed that a residential development is built on the TTU in the future. Potential receptors would include the future residents and the construction workers that build the houses. The residents could be exposed by directly ingesting the soil. Construction workers could be exposed by this route and by inhalation of fugitive dust.

Table 6. Summary of Matrix Spike/Matrix Spike Duplicate Soil Sample Results

	Concentration Added		Percent Recovered		
Analyte	**SS-19MS (mg/kg)**	**SS-19MSD (mg/kg)**	**SS-19MS**	**SS-19MSD**	**RPD**
Explosives:					
PETN	40	40	84	83	1.2
Nitrobenzene	25	20	136	125	8.4
2,4,6-TNT	25	20	104	110	5.6
2,6-DNT	25	20	132	135	2.2
2,4-DNT	25	20	112	115	2.6
HMX	25	20	136	140	2.9
RDX	25	20	116	125	7.5
2-Amino-4,6-DNT	NS	NS	NC	NC	NC
Nitroguanidine	1.0	1.0	70	70	0
Picric Acid	1.0	1.0	80	90	11.8
Nitroglycerine	20	20	84	86	2.4
Others:					
Chloride	400	400	100	100	0
Sulfate	1000	1000	80	80	0
Nitrate	100	100	100	110	9.5
Metals:					
Barium	100	NS	137	NC	NC
Beryllium	5	NS	115	NC	NC
Cadmium	5	NS	108	NC	NC
Calcium	NS	NS	NC	NC	NC
Chromium	10	NS	101	NC	NC
Copper	10	NS	144	NC	NC
Iron	NS	NS	NC	NC	NC
Manganese	NS	NS	NC	NC	NC
Magnesium	NS	NS	NC	NC	NC
Nickel	25	NS	96	NC	NC
Potassium	NS	NS	NC	NC	NC
Silver	NS	NS	NC	NC	NC
Sodium	NS	NS	NC	NC	NC
Aluminum	NS	NS	NC	NC	NC

Table 7. Summary of Blind Duplicate Soil Samples

Analyte	Concentration (mg/kg) SS-9	Concentration (mg/kg) SS-21	Relative % Difference
Explosives:			
PETN	ND	ND	NC
Nitrobenzene	ND	ND	NC
2,4,6-TNT	ND	ND	NC
2,6-DNT	ND	ND	NC
2,4-DNT	ND	ND	NC
HMX	ND	ND	NC
RDX	ND	ND	NC
2-Amino-4,6-DNT	ND	ND	NC
Nitroguanidine	0.1	ND	NC
Picric Acid	ND	ND	NC
Nitroglycerine	ND	ND	NC
Others:			
Chloride	3000	3000	0
Sulfate	ND	ND	NC
Nitrates	7.0	7.0	0
pH (unitless)	8.5	8.4	1.2
Metals:			
Barium	210	200	4.9
Beryllium	ND	ND	NC
Cadmium	32	45	34
Calcium	150000	150000	0
Chromium	14	69	132
Copper	140	1000	151
Iron	11000	11000	0
Manganese	280	370	28
Magnesium	13000	13000	0
Nickel	9	12	29
Potassium	3600	3900	8.0
Silver	ND	7	NC
Sodium	1300	1600	21
Aluminum	54000	93000	53
Zinc	240	480	67
Arsenic	ND	ND*	NC
Lead	140	21	148
Selenium	ND	ND	NC
Thallium	ND	ND	NC
Phosphorus	500	630	23
Mercury	ND	ND	NC

Separate analyses of risks to future residents were conducted for adults and children. Adults were assumed to ingest 100 mg of soil per day for 30 years. Children were assumed to ingest 200 mg of soil per day for the first 6 years of life and 100 mg per day for the next 12 years, for a total of 18 years of exposure. These are all standard assumptions (EPA 1991).

Construction workers were assumed to ingest 480 mg of soil per day for six months per year for 2 years. They were also assumed to inhale 11 cubic meters of air at work each day with a respirable dust concentration of 5 mg/m^3. The inhalation rate was derived based on an assumption of half light and half moderate activity, while the respirable dust concentration is the maximum concentration permitted by OSHA.

Under these assumptions, the hazard index (which is an estimate of the potential for health effects other than cancer) for a child was estimated to be 0.5, and the cancer risk for a child was 1×10^{-6}. For an adult resident, the hazard index was 0.1 and the cancer risk 5×10^{-7}. For a construction worker, the hazard index was estimated to be 0.2 and the cancer risk was estimated to be 4×10^{-7}. When a hazard index is less than 1 (as is the case for all the scenarios), there is little appreciable risk of humans, including sensitive individuals, suffering adverse health effects other than cancer. Cancer risks that do not exceed 1×10^{-6} (as is also the case for all the scenarios) are generally considered minimal.

The potential for adverse effects to the environment was also considered. This analysis focused on the metals cadmium, copper, lead, and zinc. Although the concentrations of these metals are high enough in some samples that exposed plants or wildlife could potentially experience adverse effects, the high samples were all collected from within or immediately adjacent to areas where OB/OD is conducted. Little or no exposure would occur in the area due to OB/OD activities and the fact that very few plants or animals are likely to live or spend time inside the sites. Furthermore, the sites themselves represent an area too small to be significant to the ecological community as a whole. In samples from locations that are representative of where plants or animals could be exposed on a regular basis, the metals concentrations are not high enough to create a potential threat to the ecological community within the TTU.

5.0 Air [40 CFR 264.601(c) and R315-8-6]

5a. Performance Standards

The environmental performance standard for the protection of the air pathway requires the prevention of any release that may have adverse effects on human health or the environment due to migration of waste constituents in the air. Specific items to be considered include:

- The volume and physical and chemical characteristics of the waste in the unit, including its potential for the emission and dispersal of gases, aerosols, and particulates;

- The effectiveness and reliability of systems and structures to reduce or prevent emissions of hazardous constituents to the air;

- The operating characteristics of the unit;

- The atmospheric, meteorological, and topographic characteristics of the unit and surrounding area;

- The existing quality of the air, including other sources of contamination and their cumulative impact on the air;

- The potential for health risks caused by human exposure to waste constituents; and

- The potential for damage to domestic animals, wildlife, crops, vegetation, and physical structures caused by exposure to waste constituents.

5b. Program Requirements

As a source of air pollutants, OB/OD units must operate in accordance with specifications provided in the state-issued hazardous waste permit. All OB/OD units must be in compliance with National Ambient Air Quality Standards (NAAQS) and Utah Department of Air Quality (UDAQ) standards, as demonstrated by the use of state-approved air dispersion modeling protocol. In addition, OB/OD facilities must evaluate whether air emissions pose a risk to human health or the environment.

The air modeling exercise completed as part of the risk assessment was conducted in accordance with UDAQ-approved guidelines. Assumptions concerning model selection, OB/OD operations, receptor locations, and emission factors are consistent with the requirements provided by UDAQ personnel.

The Gaussian-integrated puff (INPUFF) model was used to predict the concentrations of contaminants at potential receptor locations. INPUFF is an air contaminant dispersion model available through EPA used to model either a semi-instantaneous or a continuous plume being emitted from a source, taking into account a spatially and temporally variable wind speed. This model, readily available through EPA, can be used to determine the emissions that occur when the release interval of the plume cloud is less than the travel time of the cloud to the receptor.

OB and OD are short-duration release events involving the combustion/unconfined violent reaction of waste munitions without the control of combustion air, containment of the combustion reaction in an enclosed device, or control of emissions of gaseous and particulate combustion products. This combustion process occurs for approximately 1 to 5 seconds for OD activities and from 5 to 30 minutes for typical burn operations. In both cases, however, the source is considered a nearly instantaneous single release since the reactions proceed at such a rapid rate. Therefore, for all modeling scenarios, the source has been considered a nearly instantaneous source releasing large amounts of heat and gases. Since the assumptions and methodology of the INPUFF model are consistent with the site conditions found at an EOD range, the INPUFF program (version 2.3) was used to model the air emissions generated from the OB/OD treatment of waste munitions at all three sites located at the TTU.

The munitions disposed at the TTU are treated in accordance with AF-approved OB and OD treatment methods. These treatment activities are uncontained high-pressure events that release to the atmosphere combustion by-products that consist mainly of CO, CO_2 , NO_x, SO_x, and particulate matter. In addition, trace amounts of VOCs, SVOCs, and metals are released during these OB/OD treatment activities. It is possible for even small quantities of these contaminants to be dispersed over great distances and pose potential risks to both environmental and human receptors. The emissions produced from OB and OD operations have been modeled separately in order to quantitatively determine these effects.

The emission factors used in the INPUFF model were calculated using sampling data from EPA-approved field tests involving the OB/OD of waste munitions. A unit emission rate of 1,000 g/second was used for each run in the OB/OD modeling analysis. This rate was chosen arbitrarily in order to limit the number of model runs required to determine the concentrations for each compound. Although the INPUFF model has no explicit treatment of complex terrain, the elevation of the receptors with respect to the TTU have been taken into account.

Model results supported the human health and environmental assessments as discussed in Section E-5d. Additional details concerning the technical options, receptor locations, emission rates, and source description information will be provided under separate cover. Also included are diskettes containing the INPUFF model, all emission factor spreadsheets used to calculate the average concentrations for each target analyte, and site-specific concentrations generated during the risk assessment.

5c. Site-Specific Conditions

There are no structures or control systems in place at the TTU to prevent or reduce emissions of hazardous constituents to the air. However, the TTU is contained within the UTTR-North, and all adjacent lands are dedicated to military training and weapons testing, and with the exception of the buildings around the Oasis compound, the land surrounding the TTU is devoid of development.

There are no activities in the immediate vicinity that would contribute to the air emissions released during the OB/OD treatment activities; therefore, only those emissions associated with the TTU operation were taken into consideration for modeling and risk assessment purposes.

The air quality in Box Elder County meets the NAAQS, which have been adopted by the state of Utah. However, due to reports of chlorine (Cl_2)-like odors and respiratory tract irritation by Oasis residents, Hill AFB initiated an air quality monitoring program at the TTU to characterize the ambient air quality at the Oasis compound. Levels of hydrogen chloride (HCl), Cl_2, and particulate matter less than 10 microns in aerodynamic equivalent diameter (PM_{10}) were measured at three stations near the TTU. A risk assessment using the monitoring data from December 1994 to November 1995 shows that adverse effects to human health due to air concentrations of these pollutants would be unlikely [Final Report, Ambient Air Quality Risk Assessment for the TTU the UTTR-North, November 1996].

5d. Assessment of Potential Health Risks

Detailed discussions of the area's climate and topography are presented in Section B. Air dispersion modeling, as described in Section E-5b, was conducted to estimate the concentrations of OB/OD by-products in air at exposure points of interest. The dispersion modeling results were then used to estimate human health risks associated with inhalation exposure to TTU emissions.

The receptors chosen for evaluation were:

- EOD personnel that set up and monitor thermal treatment events (exposed at their surveillance point on Bug Knoll);
- A resident of the Oasis compound; and
- A recreational boater on Great Salt Lake.

The dispersion modeling results that were used for representative exposure concentrations were based on the following assumptions:

- The amount of waste munitions treated was the maximum possible (149,900 lb NEW);

- Present at treatment were the worst-case environmental conditions (e.g., temperature, wind speed, and stability class); and

- The wind blew toward the receptor(s) at all times.

The following equation from EPA (1991) was used to quantify contaminant intake:

$$(CA*IR*ET*EF*ED)/(BW*AT)$$

where:
CA = contaminant concentration in air (mg/m^3)
IR = inhalation rate (m^3/hour)
ET = exposure time (hours/day)
EF = exposure frequency (days/year)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time (days)
(365 days/year * 70 years for carcinogens)
(365 days/year * ED for noncarcinogens)

A value of 0.8 was used for the IR variable for EOD personnel, which represents the mean adult inhalation rate for males engaged in moderate activity (EPA 1991). EOD personnel were assumed to be present at Bug Knoll for 1 hour/day. That exposure time was modified by considering the wind direction data for the TTU. According to the TTU wind rose (Figure 5), wind speeds less than or equal to 15 mph (the operational limit for OB/OD operations based on ESD concerns) from the direction of the TTU toward Bug Knoll occur approximately 2.7% of the time. Therefore, the adjusted exposure time for EOD personnel is 0.027 hours/day. OB/OD operations are conducted up to 4 days/week, so that value was multiplied by 50 work weeks per year to obtain an exposure frequency of 200 days/year. This assumes that the same individual person sets up and monitors all the thermal treatment events, whereas EOD personnel are actually rotated such that one individual works at the TTU no more than 4 days/month. A value of 20 years was used for the total exposure duration, which assumes that the same individual is assigned to EOD duty for 20 years.

The mean inhalation rate of adults engaged in light activity was used for the Oasis resident and the recreational boater. It was assumed that the Oasis resident would be present at that location for 24 hours/day, and this was modified by considering that the wind direction (for winds not exceeding 15 mph) is from the TTU toward the Oasis compound approximately 9.7% of the time. Thus, the modified exposure time for the Oasis resident was 2.3 hours/day. Since Oasis residents are present at the compound 4 days/week, the exposure frequency was set at 200 days/year. It was assumed that the same individual would be present at the Oasis compound for 30 years.

The recreational boater was assumed to be present at the closest point that could be reached by a sailboat due east of the TTU for 24 hours/day, every weekend of the year (104 days/year) for 20 years. Since the wind direction (for winds not exceeding 15 mph) is from the TTU toward the hypothetical boater's location approximately 6.7% of the time, the exposure time was modified to 1.6 hours/day.

For all exposure scenarios, the mean adult body weight of 70 kg was used, as recommended by EPA (1991). Averaging time is the period over which exposure is averaged. In the case of noncarcinogens, averaging time is the product of the exposure duration times 365 days/year, because noncarcinogens are believed to exert their toxic effect only during the period of exposure.

Carcinogens, on the other hand, are thought to be capable of causing cancer at any time after the period of exposure, so the averaging time for carcinogens is 365 days/year times an assumed 70 year lifetime.

Intake of carcinogens was multiplied by the chemical-specific inhalation cancer slope factor (CSF) obtained from EPA's Integrated Risk Information System (IRIS) to obtain the incremental increase in cancer risk (i.e., above the background cancer risk of approximately 1 in 4) associated with the modeled exposure to that contaminant.

Intake of noncarcinogens was divided by the chemical-specific reference concentration obtained from IRIS to yield a hazard quotient. Hazard quotients greater than 1 indicate that adverse noncancer health effects are possible as a result of the modeled exposure to that contaminant.

If an inhalation CSF was not available for a chemical, but an oral CSF was available, the intake was multiplied by the oral CSF. If a reference concentration (for inhalation exposure) was not available for a chemical, but an oral reference dose (RfD) was available, the intake was divided by the oral RfD. No toxicity values were available for PETN, so the published RfD and CSF values for RDX, which is chemically similar to PETN, were used to evaluate PETN exposure. These measures introduce greater uncertainty to the results but allow quantification of risk that would otherwise not be possible.

Chemical-specific cancer risks were summed for each receptor, which assumes that all the carcinogenic contaminants affect the same target organ(s) in the same way and that there are no synergistic or antagonistic effects among these contaminants. Chemical-specific hazard quotients were summed for each receptor, which assumes that all the noncarcinogenic contaminants affect the same target organ(s) in the same way and that there are no synergistic or antagonistic effects among these contaminants.

The data input to the risk assessment calculations are shown in Tables 8, 9, and 10. A summary of the total risk is shown in Table 11. The sum of hazard quotients for each receptor was less than 1, indicating that noncancer health risks are not anticipated as a result of the modeled exposure. The estimated cancer risk is highest for EOD personnel, which is to be expected, since that receptor is the closest to the TTU. The Oasis resident has the lowest estimated cancer risk. Estimated cancer risks for all three receptors are near the 10^{-6} target cancer risk that is generally considered acceptable for permitting and remediation decisions.

Table 8. Estimating Risk to EOD Personnel on Bug Knoll

Chemical	Concentration (mg/m^3)	RfD (mg/kg-d)	CSF (per mg/kg-d)	Hazard Index	Cancer Risk
1,1,2,2-Tetrachloroethane	1.38E-04		0.2		1.67100E-09
1,2,4-Trimethylbenzene	3.04E-04				
1,3,5-Trimethylbenzene	3.87E-06				
1,3-Butadiene	2.38E-04		1.8		2.58230E-08
Allyl chloride	2.30E-04	0.001		4.86E-05	
Benzene	7.90E-04		0.029		1.38285E-09
Carbon tetrachloride	8.30E-06		0.053		2.65688E-11
Dichloromethane	3.39E-03				
Ethyl chloride	2.46E-05	10		5.19E-10	
Ethylbenzene	2.52E-05	1		5.33E-09	
Freon11	1.95E-05				
Freon113	5.43E-06				
Freon12	1.24E-05				
m-,p-Xylene	1.90E-05				
Methane	3.17E-03				
Methyl bromide	6.54E-05				
Methyl chloride	3.44E-05				
Methyl chloroform	1.32E-04				
O-Xylene	9.18E-06				
p-Ethyltoluene	9.99E-06				
Styrene	1.98E-04				
Vinyl chloride	2.00E-04		0.3		3.61913E-09
Vinylidene chloride	1.67E-05				
2,4,6-TNT	3.89E-05	0.0005	0.03	1.65E-05	7.05487E-11
2,4,-DNT	1.17E-05	0.002	0.68	1.24E-06	4.82225E-10
2-Nitrodiphenylamine	1.82E-06				
Benzo(a)anthracene	5.98E-07		7.3		2.63602E-10
Benzo(a)pyrene	7.76E-06		7.3		3.42147E-09
bis(2-ethylhexyl)phthalate	6.24E-05	0.02	0.014	6.60E-07	5.27790E-11
Butylbenzylphthalate	4.26E-06	0.2		4.50E-09	

Table 8 (Continued)

Chemical	Concentration (mg/m^3)	RfD (mg/kg-d)	CSF (per mg/kg-d)	Hazard Index	Cancer Risk
Chrysene	5.73E-07				
Di-n-butylphthalate	2.73E-04	0.1		5.76E-07	
Di-n-octylphthalate	1.48E-05				
Diethylphthalate	1.03E-02	0.8		2.71E-06	
Dimethylphthalate	1.29E-07	10		2.72E-12	
Fluoranthene	2.05E-06	0.04		1.08E-08	
Fluorene	2.58E-07	0.04		1.36E-09	
Hexahydro-1,3,5-...(RDX)	7.63E-02	0.003	0.11	5.37E-03	5.06597E-07
Naphthalene	8.98E-06				
Nitroglycerine	1.71E-05				
Octahydro-1,3,5,7-...(HMX)	5.81E-03	0.05		2.46E-05	
Pentaerythritol tetranitrate (PETN)	5.81E-03	0.003	0.11	4.09E-04	3.86000E-08
Phenanthrene	1.59E-06				
Phenol	1.08E-05	0.6		3.80E-09	
Pyrene	8.17E-06	0.03		5.75E-08	
Hexachlorobenzene	2.13E-05	0.0008	1.6	5.63E-06	2.06062E-09
Aluminum	2.38E-01				
Antimony	1.49E-03	0.0004		7.88E-04	
Barium	4.11E-03	0.0005		1.74E-03	
Cadmium	1.52E-02	0.001	6.1	3.21E-03	5.59376E-06
Calcium	2.58E-02				
Chromium	1.06E-03	0.005		4.48E-05	
Copper	4.88E-02				
Lead	2.13E-02				
Mercury	1.94E-06	0.0003		1.37E-06	
Nickel	6.82E-03	0.02		7.20E-05	
Potassium	2.89E-01				
Sodium	1.26E-02				
Titanium	6.17E-04				
Zinc	4.43E-02	0.3		3.12E-05	
			Total Risk:	1.17E-02	6.17783E-06

Table 8 (Continued)

Chemical	Concentration (mg/m^3)	RfD (mg/kg-d)	CSF (per mg/kg-d)	Hazard Index	Cancer Risk
Exposure Assumptions					
Inhalation Rate (m^3/hour)	0.8				
Exposure Time (hours/day)	0.027				
Exposure Frequency (days/year)	250				
Exposure Duration (years)	20				
Body Weight (kg)	70				
Averaging Time (days)-carcinogens	25550				
Averaging Time (days)-noncarcinogens	7300				

Table 9. Estimating Risk to Recreational Boater on the Great Salt Lake

Chemical	Concentration (mg/m^3)	RfD (mg/kg-d)	CSF (per mg/kg-d)	Hazard Index	Cancer Risk
1,1,2,2-Tetrachloroethane	1.82E-06		0.2		4.06E-10
1,2,4-Trimethylbenzene	3.99E-06				
1,3,5-Trimethylbenzene	5.09E-08				
1,3-Butadiene	3.12E-06		1.8		6.27E-09
Allyl chloride	3.02E-06	0.001		1.18E-05	
Benzene	1.04E-05		0.029		3.36E-10
Carbon tetrachloride	1.09E-07		0.053		6.45E-12
Dichloromethane	4.46E-05				
Ethyl chloride	3.23E-07	10		1.26E-10	
Ethylbenzene	3.31E-07	1		1.30E-09	
Freon11	2.56E-07				
Freon113	7.13E-08				
Freon12	1.63E-07				
m-,p-Xylene	2.49E-07				
Methane	4.17E-05				
Methyl bromide	8.59E-07				
Methyl chloride	4.51E-07				
Methyl chloroform	1.74E-06				
O-Xylene	1.21E-07				
p-Ethyltoluene	1.31E-07				
Styrene	2.61E-06				
Toluene	2.62E-06				
Vinyl chloride	2.20E-07		0.3		7.36E-11
Vinylidene chloride	4.47E-07				
2,4,6-TNT	5.11E-07	0.0005	0.03	4.00E-06	1.71E-11
2,4-Dinitortoluene	1.54E-07	0.002	0.68	3.01E-07	1.17E-10
2-Nitrodiphenylamine	2.39E-08				
Benzo(a)anthracene	7.85E-09		7.3		6.40E-11
Benzo(a)pyrene	1.02E-07		7.3		8.31E-10
Bis(2-ethylhexyl)phthalate	8.20E-07	0.02	0.014	1.60E-07	1.28E-11
Butylbenzylphthalate	5.59E-08	0.2		1.09E-09	
Chrysene	7.52E-09				
Di-n-butylphthalate	3.58E-06	0.1		2.94E-10	
Di-n-octylphthalate	1.95E-07				
Diethylphthalate	1.35E-04	0.8		9.52E-10	
Dimethylphthalate	1.69E-09	10		5.26E-08	
Fluoranthene	2.69E-08	0.04		1.65E-10	
Fluorene	3.39E-09	0.04		2.63E-09	
Hexahydro-1,3,5-...(RDX)	1.00E-03	0.003	0.11	4.41E-09	4.16E-13
Naphthalene	1.18E-07				
Nitroglycerine	2.24E-07				
Octahydro-1,3,5,7-...(HMX)	7.63E-05	0.05		1.75E-08	
PETN	7.63E-05	0.003	0.11	9.94E-05	9.37E-09
Phenanthrene	2.08E-08				
Phenol	1.42E-07	0.6		1.36E-10	

Table 9 (Continued)

Chemical	Concentration (mg/m^3)	RfD (mg/kg-d)	CSF (per mg/kg-d)	Hazard Index	Cancer Risk
Pyrene	1.07E-07	0.03		1.85E-08	
Hexachlorobenzene	2.80E-07	0.0008	1.6	5.24E-07	1.92E-10
Aluminum	3.12E-03				
Antimony	1.96E-05	0.0004		1.91E-04	
Barium	5.40E-05	0.0005		4.22E-04	
Cadmium	1.99E-04	0.001	6.1	7.79E-04	1.36E-06
Calcium	3.39E-04				
Chromium	1.39E-05	0.005		1.09E-05	
Copper	6.41E-04				
Lead	2.80E-04				
Mercury	2.55E-08	0.0003		3.32E-07	
Nickel	8.95E-05	0.02		1.75E-05	
Potassium	3.79E-03				
Sodium	1.65E-04				
Titanium	8.10E-06				
Zinc	5.82E-04	0.3		7.58E-06	
			Total Risk:	1.54E-03	1.38E-06
Exposure Assumptions					
Inhalation Rate (m^3/hour)	0.6				
Exposure Time (hours/day)	1.6				
Exposure Frequency (days/year)	104				
Exposure Duration (years)	20				
Body Weight (kg)	70				
Averaging Time (days)-carcinogens	25550				
Averaging Time (days)-noncarcinogens	7300				

Table 10. Estimating Risk to Oasis Resident

Chemical	Concentration (mg/m^3)	RfD (mg/kg-d)	CSF (per mg/kg-d)	Hazard Quotient	Cancer Risk
1,1,2,2-Tetrachloroethane	5.78E-07		0.2		6.69E-10
1,2,4-Trimethylbenzene	1.27E-06				
1,3,5-Trimethylbenzene	1.62E-08				
1,3-Butadiene	9.92E-07		1.8		1.03E-08
Allyl chloride	9.61E-07	0.001		1.30E-05	
Benzene	3.30E-06		0.029		5.53E-10
Carbon tetrachloride	3.47E-08		0.053		1.06E-11
Dichloromethane	1.42E-05				
Ethyl chloride	1.03E-07	10		1.39E-10	
Ethylbenzene	1.05E-07	1		1.42E-09	
Freon11	8.14E-08				
Freon113	2.27E-08				
Freon12	5.19E-08				
m-,p-Xylene	7.92E-08				
Methane	1.32E-05				
Methyl bromide	2.73E-07				
Methyl chloride	1.43E-07				
Methyl chloroform	5.52E-07				
O-Xylene	3.83E-08				
p-Ethyltoluene	4.17E-08				
Styrene	8.28E-07				
Toluene	8.34E-07				
Vinyl chloride	6.99E-08		0.3		1.21E-10
Vinylidene chloride	1.42E-07				
2,4,6-TNT	1.63E-07	0.0005	0.03	4.39E-06	2.82E-11
2,4-DNT	4.90E-08	0.002	0.68	3.31E-07	1.93E-10
2-Nitrodiphenylamine	7.61E-09				
Benzo(a)anthracene	2.50E-09		7.3		1.05E-10
Benzo(a)pyrene	3.24E-08		7.3		1.37E-09
bis(2-ethylhexyl)phthalate	2.61E-07	0.02	0.014	1.76E-07	2.11E-11
Butylbenzylphthalate	1.78E-08	0.2		1.20E-09	
Chrysene	2.39E-09				
Di-n-butylphthalate	1.14E-06	0.1		1.54E-07	
Di-n-octylphthalate	6.20E-08				
Diethylphthalate	4.28E-05	0.8		7.23E-07	
Dimethylphthalate	5.38E-10	10		7.27E-13	
Fluoranthene	8.57E-09	0.04		2.89E-09	
Fluorene	1.08E-09	0.04		3.63E-10	
Hexahydro-1,3,5-...(RDX)	3.18E-04	0.003	0.11	1.43E-03	2.03E-07
Naphthalene	3.75E-08				
Nitroglycerine	7.13E-08				
Octahydro-1,3,5,7-...(HMX)	2.43E-05	0.05		6.55E-06	
PETN	2.43E-05	0.003	0.11	1.09E-04	1.54E-08
Phenanthrene	6.62E-09				
Phenol	4.51E-08	0.6		1.01E-09	

Table 10. (Continued)

Chemical	Concentration (mg/m^3)	RfD (mg/kg-d)	CSF (per mg/kg-d)	Hazard Quotient	Cancer Risk
Pyrene	3.41E-08	0.03		1.53E-08	
Hexachlorobenzene	8.90E-08	0.0008	1.6	1.50E-06	8.25E-10
Aluminum	9.92E-04				
Antimony	6.23E-06	0.0004		2.10E-04	
Barium	1.72E-05	0.0005		4.63E-04	
Cadmium	6.34E-05	0.001	6.1	8.56E-04	2.24E-06
Calcium	1.08E-04				
Chromium	4.42E-06	0.005		1.19E-05	
Copper	2.04E-04				
Lead	8.90E-05				
Mercury	8.12E-09	0.0003		3.65E-07	
Nickel	2.85E-05	0.02		1.92E-05	
Potassium	1.21E-03				
Sodium	5.24E-05				
Titanium	2.58E-06				
Zinc	1.85E-04	0.3		8.33E-06	
Exposure Assumptions			**Total Risk:**	3.14E-03	2.47E-06
Inhalation Rate (m^3/hour)	0.6				
Exposure Time (hours/day)	2.3				
Exposure Frequency (days/year)	250				
Exposure Duration (years)	30				
Body Weight (kg)	70				
Averaging Time (days)-carcinogens	25550				
Averaging Time (days)-noncarcinogens	10950				

Table 11. Human Risk Estimates

Receptor	Error! Bookmark not defined. **Hazard Index**	**Cancer Risk**
EOD Personnel	1.17E-02	6.18E-06
Recreational Boater	1.54E-03	1.38E-06
Oasis Resident	3.14E-03	2.47E-06